ANALOG DEVICES

AN-256
APPLICATION NOTE

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Accurately Testing Op Amp Settling Times

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BASIC EQUIPMENT FOR TESTING op-amp settling times consists of a high-quality (and expensive) "flat-top" pulse generator as input to the DUT, a DUT test jig with power supply and bypass capacitors at op-amp-socket supply pins, and an oscilloscope to process and display test output. Proper use of a pulse generator containing a reed switch can achieve the same result.

Settling-time tests require flat-waveform inputs because, throughout most of their frequency ranges, op-amps behave as integrators. Therefore, their error-signal outputs are derivatives of input signals. The derivative of an ideal-square-wave input consists of a pulse at each edge transition and zero everywhere else. Any aberrations in the input square wave appear in the error signal. Many bench-top square-wave generators exhibit thermal "tails" and other problems that limit their suitability for measuring settling times.

Figure 1 shows a practical circuit for measuring the settling time of high-speed op amps. In this case, a commercial flat-top pulse generator

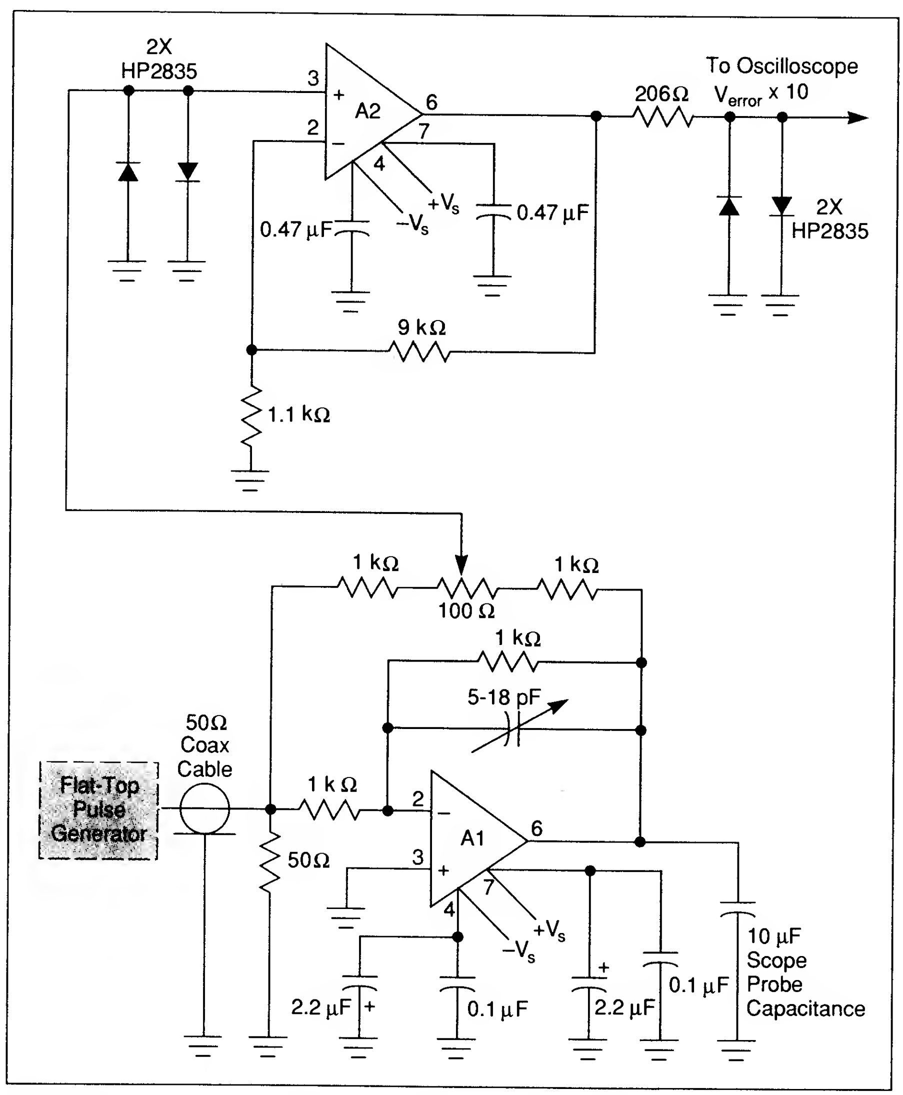

FIGURE 1. A practical circuit for measuring high-speed-op-amp settling time. The DUT-output-to-scope-input connection requires 50 Ω coax less than one foot long.

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drives the input. Figure 2 shows the scope's output waveform for a typical high-speed device. The error-signal output from DUT *A1* is clamped, then amplified by op-amp *A2* and clamped again. *A2*, a very high-speed device, provides a voltage gain of 10, amplifying the error-signal output by a factor of five. The clamps, each consisting of two high-speed Schottky diodes, prevent overloading the input of *A2* and the scope preamp. An unclamped high-intensity "tail" could exceed the desired error signal itself. We chose a Tektronix scope preamp type 7A26 because it can recover from the 0.4-V clamped signal quickly enough to accurately measure the DUT's 135-ns settling time.

This test setup uses coaxial cable to connect the pulse-generator output to the test-fixture input and to connect the fixture output to the oscilloscope-preamp input. Coax provides shielding between input and output signals and maintains a constant impedance throughout the frequency range. Audio-type shielded or unterminated coax wiring would produce widely varying responses with changing frequency, causing gross measurement errors.

Unfortunately, high-quality flat-top pulse generators are both expensive and difficult to find. A pulse generator incorporating a reed-relay switch, such as the arrangement in Figure 3, can also provide high-quality flat-top pulses. The contact release of a mercury-wetted reed relay creates an extremely fast current-flow interruption. Note that the DUT-output/oscilloscope connection must be both short and direct. For example, the DUT card can plug directly into the preamp input using a male chassis-mount BNC connector to convey the signal and hold the card onto the oscilloscope.

Figure 4 illustrates the reed switch's internal workings, showing that the circuit becomes totally passive in this arrangement. Therefore, pulse quality depends solely on coax-cable settling time. For pulse edges of about 10 ns and faster, settling time can vary dramatically from case to case. This design permits bypassing the circuit, when necessary. However, reed switches only permit very low repetition rates, from about 100 Hz to about 2 kHz. A test can overcome this limitation by capturing and averaging repetitive waveforms on a digital-storage scope.

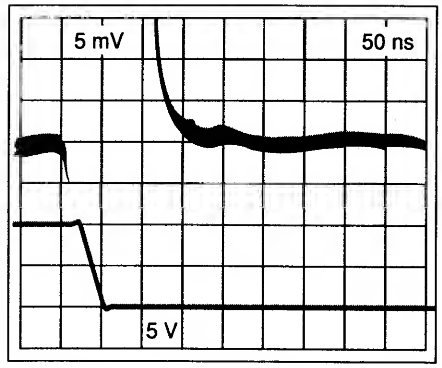

FIGURE 2. The oscilloscope's output waveform for a typical high-speed device, using the equipment in Figure 1.

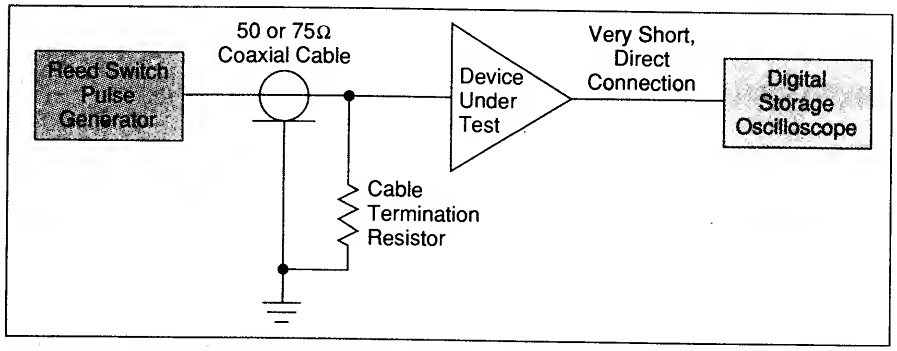

FIGURE 3. A test circuit including a pulse generator that contains a reed-relay switch can provide a flat-top pulse of the highest quality.

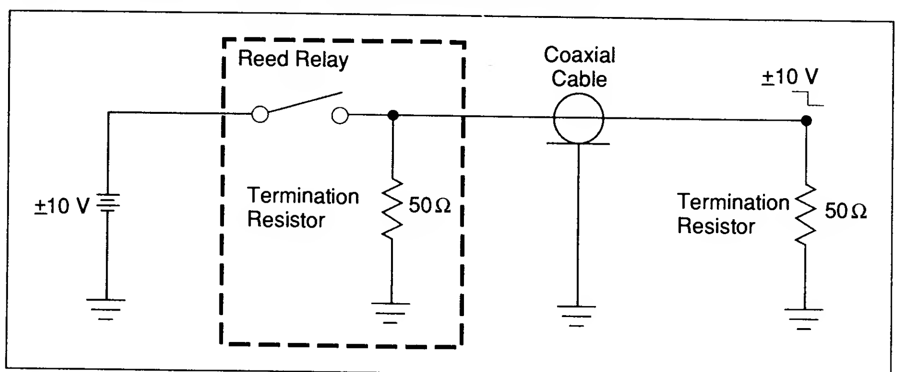

FIGURE 4. The reed switch's internal workings.